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March 1994

US Army Corps of Engineers
Waterways Experiment Station

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Legacy Resource Management Program

Legacy Earth Resource Workshop

Proceedings of the March 1993 Earth Resource Workshop, Eglin Air Force Base, Florida

by *David M. Patrick*
University of Southern Mississippi

Paul E. Albertson, Lawson M. Smith

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Prepared for Office of the Deputy Assistant Secretary of Defense for the Environment

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Proceedings of the March 1993 Earth Resource Workshop, Eglin Air Force Base, Florida

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Final report

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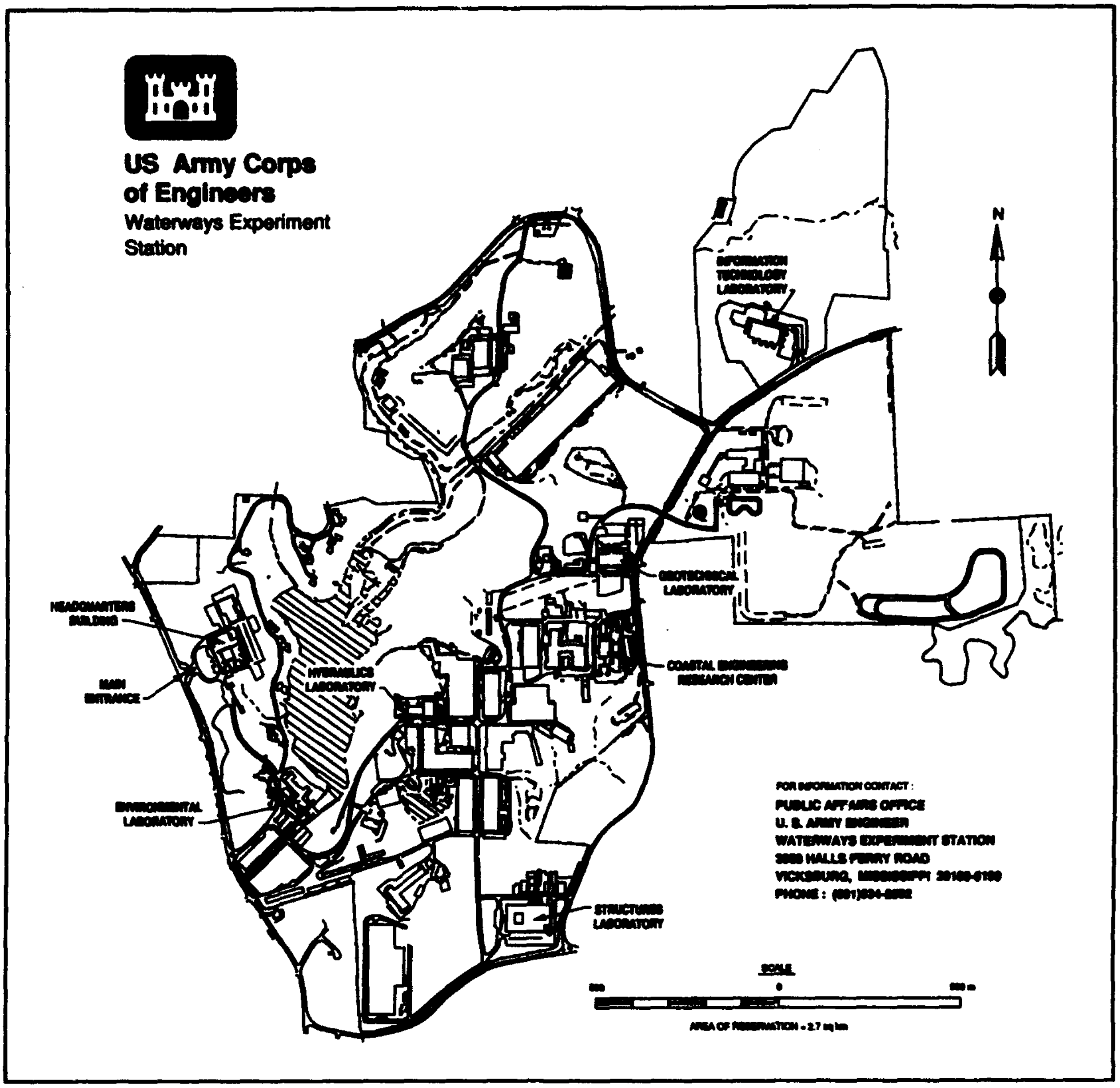

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Preface

This work was performed during December 1992 through April 1993 at the U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi. The work was conducted under the authority of the Legacy Resource Management Program under the Office of the Deputy Assistant Secretary of Defense for the Environment, U.S. Department of Defense (ODASD-E).

The work and report preparation were performed by Dr. David M. Patrick, University of Southern Mississippi (USM), and by Mr. Paul E. Albertson and Dr. Lawson M. Smith, Engineering Geology Branch (EGB), Earthquake Engineering and Geosciences Division (EEGD). Dr. Smith supervised the work and is the Earth Resources Task Area Manager in the Legacy Program. General supervision was provided by Mr. Joe Gatz, Chief, EGB; Dr. A.G. Franklin, Chief, EEGD; and Dr. William F. Marcuson III, Director, GL.

Mr. Thomas E. Baca was Deputy Assistant Secretary of Defense (Environment), Mr. L. Peter Boice was the Legacy Project Officer at ODASD-E. Dr. J. Douglas Ripley was the coordinator for Natural Resources Management at the U.S. Army Engineer Housing and Support Center (USAEHSC), Fort Belvoir, Virginia, through whom the Earth Resource Task Area was coordinated.

The writers acknowledge the assistance of the workshop speakers who contributed abstracts to this report and the following individuals: COL Doug Hardin, USAF, Messrs. Michael Clark, Rick McWhite, Mike Camizzi, and others of Eglin Air Force Base; Ms. Pamela M. Klinger (Office Chief of Engineers) who provided transcripts of the presentations; Mr. Mike Waring and Dr. Paul Nickens, Envronmental Laboratory, WES, for moderating discussion sessions; Gary Hennington and Chris Gellasch of WES for data processing; and Clint Roberts (USM) for report preparation.

At the time of publication of this report, the Director of WES was Dr. Robert W. Whalin. The Commander was COL Bruce K. Howard, EN.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To obtain
acres	4,046.873	square meters
feet	0.3048	meters
inches	2.54	centimeters
miles (U.S. statute)	1.609347	kilometers

1 Introduction

Purpose

The purpose of this report is to describe and document the Legacy Earth Resource Workshop held at Eglin Air Force Base (AFB), Florida, during the period 9-11 March 1993. This workshop was held under the auspices of The Legacy Resource Management Program (LRMP) and was sponsored by Eglin AFB. It was coordinated by the U.S. Army Engineer Waterways Experiment Station (WES). The workshop was held at Eglin because it is one of the larger Department of Defense (DoD) Major Range and Test Firing Bases (MRTFB) and there are a number of environmental issues and sensitive ecosystems at the base. Also, it is the location of two Legacy Earth Resource demonstration projects and Eglin AFB personnel have played important roles in the LRMP.

Legacy Background

The LRMP was enacted through the FY91 Defense Appropriations Act (Public Law 101-511) which mandated that this program:

a. Establish a strategy, plan, and priority list for identifying and managing significant biological, geophysical, cultural, and historical resources existing on DoD land.

b. Provide stewardship of all DoD controlled or managed air, land, and water resources.

c. Protect significant biological systems on these lands.

d. Establish standard DoD methodology for resource management.

e. Protect, inventory, and conserve archaeological artifacts.

f. Inventory DoD resources.

g. Develop programs to restore and rehabilitate altered or degraded habitats.

h. Establish educational, public access, and recreation programs.

i. Inventory, protect, and conserve property and relics of DoD pertaining to the Cold War.

The LRMP also consists of specific Task Areas for biological, cultural, and geophysical (earth) resources, data management, survey of current programs; education, recreation, and public awareness; Native Americans and settlers, project management procedures, decision framework, biodiversity, training, and the Cold War. LRMP demonstration projects are also being conducted at DoD installations across the country.

Earth Resources Task Area (ERTA)

The Earth Resources Task Area (ERTA), managed at WES, is a part of the LRMP Program Development. Earth resources refers to the earth as a planet which includes the materials and processes of the solid earth (lithosphere), the hydrosphere, and the atmosphere. The general mission the ERTA is to "Develop through coordination with other agencies, private organizations, and DoD professionals, the specifications and methods for exemplary management programs in the areas of geophysical (earth) resource." The specific mission is to support the LRMP by developing strategy, plans, and priority lists for identifying, inventorying and managing earth resources, and by determining the interrelationships between earth resources, and biological and cultural resources. The ERTA is accomplishing these missions through technical reports and technology transfer, workshops, and management of earth resource demonstration projects at EAFB (Florida), White Sands Missile Range (New Mexico), Fort Leonard Wood (Missouri), Dugway Proving Ground (Utah) and the Naval Surface Weapons Center Crane (Indiana).

The ERTA has proposed that comprehensive resource management and stewardship at installations require a thorough understanding of earth resources as these apply to such familiar needs as clean water supplies, construction materials, energy sources, and clean air. Besides these more obvious needs, however, are interrelationships between earth resources and cultural and biological resources. The ERTA has also proposed that, in many instances, earth resources are critical factors affecting the distribution and character of both cultural and biological resources and, if this is the case, for resource management to be comprehensive, it must be holistic and conducted in an integrated fashion.

Workshop Objectives and Participants

The goals of this workshop were to:

a. Provide natural and cultural resource managers at DoD installations an opportunity to learn about earth resources management activities in DoD.

b. Review the results and recommendations of Earth Resources Task Area draft reports.

c. Receive input from resource managers in the field.

d. Help identify issues and opportunities for earth resources stewardship.

e. Contribute to the development of a strategic plan for further earth resource activities and demonstration projects.

Workshop speakers were individuals from within DoD, academia, consultants, all having participated either in LRMP, or who had conducted integrated resource management studies in the private sector. The biographies of the speakers are given in Appendix A. Natural and cultural resource management personnel across DoD were extended invitations to attend the workshop. Those attending represented a wide spectrum of interests from management to the working level. A list of attendees is given in Appendix B. The attitudes and perceptions of the participants were evaluated through preworkshop and postworkshop questionnaires; the responses to the questionnaires are given in Appendix C.

2 Earth Resources

Overview of DoD Earth Resources

Lawson M. Smith
U.S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

Earth resources consist of the elements of the lithosphere, hydrosphere, and atmosphere and are all of the abiotic natural resources. DoD installations are blessed with an abundance of a wide variety of energy resources, strategic minerals, soil, and water, which are all critical natural resources. Many of these earth resources, like oil and gas, are important sources of revenue to DoD. Some earth resources, like contaminated groundwater, are the object of tremendous expenditures of money to restore them. It is also important to remember that earth resources are not only materials but processes as well, like stream flow wind, and tides.

Earth resources are important because they support life as well as the installation mission. Many earth resources are depletable and are being significantly impacted by installation activities. Poorly managed earth resources may result in major environmental problems which are costly to solve. However, many earth resources respond positively to knowledgeable stewardship. Earth resource information is also important because it is the foundation for integrated cultural, biological, and earth resource stewardship.

Despite present shortcomings in earth resources stewardship in DoD, the legal and policy foundation for earth resources management is substantial. A number of the major environmental laws passed over the last 25 years specifically deal with earth resources, including National Environmental Policy Act (NEPA), Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Superfund and Amendments and Reauthorization Act (SARA), Toxic Substances Control Act (TSCA), the Clean Air Act, the Clean Water Act, and the Wild and Scenic Rivers Act. All of the departments within DoD have a number of specific regulations regarding earth resource conservation, preservation, and exploitation.

The DoD presently manages earth resources in a variety of ways, directly and indirectly. The DoD complies with state and Federal regulations covering earth resources. DoD enters into partnerships with state and Federal agencies to manage its earth resources. Some installations have or participate in special resource management programs like geothermal energy and regional groundwater allocation. DoD installations have detailed master plans that include some earth resources planning. Most large installations have significant natural resources management programs which address some issues in earth resources management.

There are a number of problems facing earth resources stewardship in the DoD. There is a deficit of resource managers trained in earth science. The competition for funding earth resource management projects is stiff in natural resource management programs. There is a need to develop stronger institutional support for earth resources stewardship. Standard methods for identification, inventory, and management of earth resources have not been identified. Many cultural and natural resource managers do not understand their need for specialized types of earth resources information, consequently there are false expectations about the applicability of some existing earth resource data. Earth resources management in the DoD is presently highly fragmented in different installation functions. Addressing these problems will greatly enhance earth resource management toward our goal of integrated resource stewardship.

Geological Assessment—The Foundation of Environmental Management

Walter Schmidt
Florida Geological Survey
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Too often, when an environmental assessment of an area is required, and the background scientific literature is consulted regarding endangered or threatened species, critical habitat, and general ecosystem analysis, the basic foundation of our earth systems is ignored. The general emphasis in today's environmental review is biological. While this is clearly an important component of the overall assessment, it is not the foundation for truly understanding why many environments and ecosystems exist today. Forested uplands, dry inland ridges, wetlands, and coastal swamps to name a few, all owe their existence to the local shallow subsurface geology and hydrogeologic regime. All species exist in the habitat for which they are best adapted. Why does an area function as a wetland? Is it a groundwater discharge area? Is it a low relief karst prairie, or is it part of an episodic fluvial system? Why do certain species of plants grow in selected defined regions? Are they dependant on the near surface mineralogical nutrient sources? Are they in need of well drained sediments? Do they require a specific groundwater or surface-water chemistry? A clear understanding of the natural systems which includes the geologic foundation of

our environment is the most essential aspect of any environmental assessment. A review that considers only the living part of the ecosystem, while ignoring the basic geology that gave rise to the terrain, will be seriously and fundamentally incomplete.

Landforms and Resource Management

Stanley A. Schumm
Resource Consultants & Engineers, Inc.
Fort Collins, Colorado

The surface of our planet is continually changing, but at greatly different rates, and the rates can vary greatly through time. Studies of land forms (hillslopes, rivers, alluvial fans, coastlines, dunes) by geomorphologists and others have documented such changes and their causes. Quantitative descriptions of landforms, when coupled with information on their history, provide a basis for the prediction of change through time. Equally important is the recognition of sensitive landforms, that are susceptible to dramatic change, as a result of human and/or natural influences. In addition, it is now recognized that landforms often respond in a complex manner. For example, a series of erosional and depositional events may follow a single human or natural impact on the landscape.

Geomorphic studies should be an integral part of resource management. Plants and animals are affected by landform modifications by humans or by the natural adjustments of a landscape (meander cutoffs, gullying, slope failure). The ability to anticipate such changes and to predict subsequent adjustments will add an additional cost-effective dimension to land management.

Paleontological Resources at DoD Installations

David Gillette
Southwest Paleontology Foundation, Inc.
Salt Lake City, Utah

Two paleontological investigations are underway for the DoD. One is in Utah looking at packrat paleontology, the other involves preparing a users manual on paleoenvironmental studies for DoD installations. The emphasis of this work is largely interdisciplinary and our staff includes an archaeologist having an interest in geology. We are looking at rodents in order to understand changes in paleoenvironment. A spinoff from rodent research comes from studying material collected by packrats. The packrat middens accumulated in caves over the last 25,000 years and reveal information on the paleoenvironment. Packrats gather seeds, bird feathers, bones, etc. Using radiocarbon dating, we can date items and thereafter

study paleoenvironmental changes. Packrat middens occur all across northern America. In many sites in Utah, air is very arid and materials undergo little degradation.

The Utah project focuses on lakeside caves and caverns in limestone. Caves are dissolution features in karst topography. The methods include blocking off sections of cave alluvium. We take core samples for study maintaining stratigraphic relations. There is great potential for obtaining and describing large species lists from these samples in which changes in speciation may be seen. These data can be used for correlation with other data from other sites or locations. On installations that have been excluded from human activities, there are significant opportunities to get data from pristine sites. In nearby Danger Cave, the microstratigraphy correlated well with a succession of radiocarbon dates, and the younger deposits contained data on the feeding habits of early man. Samples and cores collected in the caves or from other sites are taken to the lab where the materials are sifted, and the easily recognized rodent teeth and bones are picked out of the samples.

We have also worked on a related project in Guam which has been highly impacted by man. The only pristine forests that remain on the island are on military lands. Denuding of forests results in increased erosion which results, in turn, in increased sediment loads in the surrounding ocean. These sediments have impacted fish populations. Reforestation efforts are underway in Guam and this work involves reintroduction of tree species no longer present on the island.

Geologic Mapping and Fort Irwin, California

Rene Quinones
Directorate of Public Works
Fort Irwin, California

The geologic mapping of Fort Irwin and the National Training Center (NTC), California, is a never ending process. The post is located on the edge of the Eastern California Shear Zone which is a branch of the San Andreas fault. In June 1992, a magnitude 7.3 quake rocked the area lifting the post 10 inches in 30 seconds. Over 50,000 small quakes have been registered during the past year. Military operational requirements do not allow for long-term field work by geologists. In addition, live munitions in impact areas do not allow field work in some areas. The use of remote sensing, LANSAT images, has allowed the post to identify rock structures, fault systems, sediment migration, possible geothermal reserves, and operational surface disturbance of the desert landscape. By using LANSAT images provided by NASA, further enhanced by the geological staff at Louisiana State University, Baton Rouge, Louisiana, the NTC is having the Waterways Experiment Station (WES) develop a geographic information system which will be the foundation for biological, archaeological, and land use studies.

In addition, a new program is the adaptation of the Remote Minefield Detection System developed at WES, for the mapping of the endangered desert tortoise. The concept is to use laser and thermal-based technology to overfly large desert areas to map tortoise locations. Current methodology is to use biology teams to sweep areas up to three times and marking each new tortoise found. Field calibration of the equipment has been completed and test overflight is being scheduled for the near future.

3 Cultural Resources

Geomorphic Applications to Cultural Resource Management at Fort Ord, California

John Isaacson and Donald L. Johnson
U.S. Army Engineer Construction Engineering Research Laboratory (USACERL)
Champaign, Illinois

This study assessed the potential for prehistoric archeological sites on Fort Ord, California, for the Section 106 (National Historic Preservation Act) process associated with installation disposal under the 1991 Base Realignment and Closure Action. Defining the geomorphic and paleoenvironmental context of the installation provides important information for the design of an archeological survey. Fort Ord can be divided into five physiographic zones based on landform age, drainage characteristics, and soil classification. These five physiographic regions were assessed for their potential to contain archeological sites. Based on these assessments, high and low probability areas were defined. The geomorphology of Fort Ord has significant implications for where to, and where not to survey for archeological sites on the installation.

The fort is located in the southern third of Monterey Bay, California. Along its north/south axis it is bounded by a series of local east/west trending faults. The northern border of the installation is defined by the fault-entrenched Salinas River which abuts against a bluff face overlooking the Salinas Valley. The southern boundary of the installation is also defined by the fault-entrenched Canyon Del Rey drainage. From west to east, the installation can be divided into five physiographic zones. The zones are beach strand, the active modern dunes, a zone of older stabilized holocene dunes, a zone of relic Pleistocene dunes overlying indurated Aromas sands and the Paso Robles Formation, and an area of dissected uplands and integrated drainages which flow northward to the Salinas River.

Three results of our research have direct implications for the design of the archaeological survey. First, a comparison of the 1941 and 1989 aerial

photos of the coastal strip, adjacent to Stillwell Hall, indicates the massive coastal erosion which has taken place in the 45-year span between photos. Each photo was scanned and imported as an image into the Geographical Resource Analysis Support System (GRASS), the geographical information system developed at USACERL. These images were georectified and displayed as overlays to compare coastline regression between the two images. From these data, it was clear that as much as 80 meters of erosion has taken place in the last 45 years. If this rate of coastline regression is projected back over the past 6000 years, it is clear that few if any prehistoric sites adjacent to the beach strand, located in the active dunes have survived the coastline erosion. Therefore, these areas are considered having a low probability for archeological sites.

From the correlation of water well logs across the installation, and published data on the geomorphology of the Salinas Valley, a reconstruction of the late Pleistocene and early Holocene Salinas Valley was possible. From these data, an ancient, and now buried bluff line was identified that represents cliffs, similar to the modern cliffs adjacent to the Salinas Valley, that overlooked a large ancient estuary. This ancient Salinas estuary existed between 16000 and 6000 BP under what is now the northwestern half of Fort Ord. This buried bluff which runs along Inter-Garrison Road and south along the limits of the Aromas sands/Paso Robles Formations, should have been an important location for early prehistoric sites exploiting the rich biota of the ancient estuary.

The third formation of interest to our study was wet cycle lakes which exist in the relic Pleistocene dunes on Fort Ord. These stabilized dunes are characterized by internal drainage, and lakes are formed by runoff during unusually wet years, that collects in dune "blowouts" which overlie the cemented durapans of the Aromas sands/Paso Robles Formations in the eastern third of the installation. Wet cycle lakes are rare in California and contain many indigenous California species of plants and animals, and were probably important resource zones in prehistory. These "wet cycle" lakes have a high probability of having associated archeological sites.

By placing Fort Ord in its geomorphic and paleoenvironmental context, an archeological survey was designed that focused on areas of the installation that had the highest probability of producing positive results. To test the reconstruction, 10 percent of the low probability areas was also sampled.

Geoarchaeological Approach to Cultural Resource Management

Robert Dunn
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Little Rock, Arkansas

A geoarchaeological approach to cultural resource management is presented which integrates geomorphological landform analysis, the GIS software package GRASS, and modem-accessed as well as in-house computerized databases. The geoarchaeological approach is similar in concept to that developed by Karl Butzer in *Archaeology as Human Ecology*. Landforms with horizontal and vertical dimensions become the principal units of analysis. Landforms are conceptualized as 3-dimensional repositories of buried cultural deposits. The proper concern of Corps archaeologists as Federal land managers becomes the management of this 3-dimensional cultural landscape, the repository of the Native and Euro-American archaeological record.

Geomorphological analysis utilizing aerial photography, mechanized coring, and laboratory soil analysis is used to delineate landforms on 7.5 minute topographic quadrangles. The potential for buried cultural deposits is assessed through field work which integrates geomorphology and archaeology and ground-truths the site distribution model. High site potential landforms such as natural levee formations, tributary terraces, colluvial talus slopes, etc., are defined for each project. The age and depth of buried surfaces and their spatial correlation is a major goal of this analysis.

We argue that management of these landforms is an effective way to preserve buried cultural deposits when funds for National Register eligibility testing are not available or when there are insufficient funds to perform 100 percent archeological surveys of large tracts of land. Furthermore, this geoarchaeological approach allows scarce Federal funds to be used most efficiently to pinpoint areas where intensive survey would be most productive, e.g., in the review of permit applications for the Corps Regulatory Program and the completion of inventories required by Section 110 of the National Historic Preservation Act.

The geoarchaeological approach taken is ideally suited to the preparation of Historic Preservation Management Plans at military installations and Corps civil works projects (reservoirs, navigation pools, etc.) in the absence of completed cultural resource inventories. Examples of this approach are given at Fort Chaffee, the Pine Bluff Arsenal, the McClellan-Kerr Arkansas River Navigation System, Bull Shoals Dam, and Norfork Lakes.

The Unified Landscape—Earth Science, Archaeology, and Resource Management

Archaeological Assessments, Inc.
Nashville, Arkansas

Archaeological Assessments, Inc. (AAI), a cultural resources management (CRM) firm based in Nashville, Arkansas, has developed a CRM framework that is based on a culturally annotated landscape model described below. Working with earth scientists, many from the U.S. Army Engineer Waterways Experiment Station, the framework was developed from extensive CRM projects conducted by AAI for the U.S. Army Engineer District, Little Rock. These projects include the U.S. Military Garrisons at Fort Chaffee, the Pine Bluff Arsenal, and various Civil Works projects in the Arkansas and White River systems of Arkansas. The video presented here focuses primarily on the development of CRM plan for Fort Chaffee, Arkansas.

Development of CRM framework at Fort Chaffee was accomplished through the five sequential steps. Initially, a geomorphological reconnaissance study identified the landforms and geomorphic processes of the landscape on and in which the archaeological record occurs. The second step involved annotation of the geomorphological maps with the existing archaeological record. Projections were then made about the probable distribution of the extant archaeological record. These projections were then tested in the field through survey of sample areas and site evaluation. During field testing a landscape model was produced consisting of the spatial distribution of landforms which have various levels of archaeological potential and the geomorphic processes which have impacted the archaeological record in various ways. The culturally annotated and field verified landscape model was then incorporated into a GIS to form the framework for identification, evaluation, and management of the cultural resources. The use of this framework resulted in the location of over 900 cultural resources at Fort Chaffee, of which over 70 have been formally evaluated to determine their eligibility for nomination to the National Register of Historic Places. Additionally, another 89 cultural resource locations are actively undergoing management at Fort Chaffee.

Because the management framework was organized in a spatially coherent and problem oriented manner, it provided the context for addressing the installation's lcng and short term cultural resource management needs. The short term needs include the never ending stream of small projects associated with accomplishment of the installation mission. The framework also provided the basis for accomplishing long term goals such as the ultimate development of the installation CRM Plan.

Development of the earth sciences based cultural resources management framework provided benefits above and beyond its practical benefits in CRM. The development process helped to underscore the important

realization that cultural, like biological resources, are elements of a more comprehensive landscape system. This realization has far-reaching consequences for the establishment of programs for which stewardship, not just compliance, is the primary management goal.

4 Biological Resources

Integration of Biological Resources and Earth Resources Management

Charles V. Klimas
L. C. Lee & Associates, Inc.
Seattle, Washington

Managers of biological resources recognize that physical factors constrain the characteristics of plant and animal communities. Climatic conditions, geologic setting, soil chemistry, and similar considerations are routinely evaluated by professional biologists formulating management plans. Often, however, we view earth resources as static conditions without due consideration of process, and without attention to their landscape context.

Riparian ecosystems clearly illustrate the importance of dynamics within physical environments. In streamside and floodplain settings, ecosystem structure and function are closely tied to physical processes, and the interactions among physical and biological systems are complex. Hydrologic regimes, stream meander behavior, sediment movement patterns, and a variety of other factors influence biological communities associated with the stream system, and the biota in turn can moderate the physical processes.

Physical features and processes also affect biological functions by determining the spatial arrangement of ecosystems on the landscape. Plant communities usually change gradually along physical gradients (e.g., elevation, moisture), but those associated with stream corridors slice across gradients to connect systems that are entirely dissimilar. Animal populations are superimposed on the geomorphic and vegetational mosaic, differentially exploiting resources and moving through and between ecosystems to meet various life requirements.

From the resource management standpoint, it is particularly important to recognize such dynamic and spatial interactions whenever manipulations of the physical system are proposed. Dam operations, groundwater

withdrawal programs, leveeing, mining, roadbuilding, agriculture, and a wide spectrum of other activities can profoundly alter the physical controls on ecosystems as well as the interdependence of ecosystems at the landscape scale. Managers with responsibility for very large, contiguous blocks of land (such as military bases) have an unusual opportunity to plan and work at the landscape level where geomorphic context can be fully considered.

The landscape perspective can be particularly effective where ecosystem restoration is an option. Careful evaluation of the physical setting and controls on an ecosystem can focus restoration activities to produce very large gains in biological function and integrity from proportionally small but strategic restoration actions.

Geomorphology and Habitats of Bayou Darters in Mississippi

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[1]Department of Geology and [2]Department of Biological Sciences
University of Southern Mississipp
Hattiesburg, Mississippi

Geologic and geomorphic studies were conducted in the Bayou Pierre basin in southwestern Mississippi in order to further understand the physical habit of the Federally-listed bayou darter (*Etheostomoma rubrum*) endemic to this basin. This fish is referred to the subgenus Nothonotus, a group of 16 species which typically inhabits high gradient streams with coarse substrata.

Detailed field counts and population studies conducted by biologists over the last five or six years, as well as earlier reconnaissance-level studies conducted over tens of years, indicated that the dwindling populations of these fish were found further and further upstream over time. Biological field work also showed that downstream reaches had been abandoned, and that sampling sties along the stream were undergoing significant erosional change. Geological investigations, consisting of field work, and interpretations of historic and modern aerial photography and topographic maps, revealed that headcutting is occurring throughout the upper reaches of the basin.

Comparison of knickpoint locations with darter habitats showed that habitats were located near knickpoints. The occurrence of darter populations in the vicinity of knickpoints is believed to result from the darter's requirements of swift (mean velocity = 79 cm/s), shallow water, with firm, coarse substrata (mean size = 16-32 mm) occurring near the knickpoint. As the knickpoint migrated upstream, the habitat was abandoned in favor of locations upstream due to increased sedimentation, flatter gradients, and decreased water velocity at the old site.

Biodiversity and Its Determinants

Anthony J. Krzysik
U.S. Army Construction Engineering Research Laboratory
Champaign, Illinois

The Ecological Society of America has recognized three priority research agenda, these are: global change, sustainable ecological systems, and biological diversity. Biodiversity is the variety and variability of biological organisms within a specific spatial and temporal context. It does not mean just maximizing the species diversity in one area. The study of biodiversity is fundamentally identical to the study of ecology, both possessing a comparable hierarchical structure. Biodiversity is spatially and temporally dynamic, representing the net effects of speciation, extinction, immigration, and emigration. Geological processes, climate, and hydrology are physical factors that are demonstrated to be the primary and fundamental determinants of the origin and maintenance of biological diversity.

Ecological processes and species interactions additionally contribute to biodiversity. How do we evaluate biodiversity? Number of species, complexity and pattern of metapopulation structure, genetic richness/number of subspecies and/or demes, number of native species, number of endemic species, number of rare or listed species, taxonomic rank richness (higher taxa richness), richness in ecological functional groups, importance of Keystone species, vicariance biogeography (evolutionary centers), pristine versus disturbed ecosystems, natural versus management processes, and economic/social values must be considered.

Extinctions are constantly occurring, but we also have reinhabiting of areas. There is also genetic variability which is what adapts the biota to the local conditions and allows for species adaptability in a changing environment. Biodiversity is at a dynamic disequilibrium which, therefore, makes it difficult to manage. Have genetic processes (mutation), speciation, immigration coevolutionary process, or release of exotics occurred?

Physical parameters that cause biodiversity include: geomorphology (topography, texture of materials, etc), hydrology, climate, natural disturbances (fire, flooding, disease, etc.), and anthropogenic disturbances and stresses (man-induced such as fire suppression, construction of dams and levees, urbanization, release of exotic species, resource extraction, etc). These parameters are all interrelated. Also, as plant species and/or diversity change due to changing conditions (often man-induced),there will be an impact on animal life diversity. Altered systems are reducing numbers of species and biomass in a number of regions. For ecosystem sustainability, we need to understand the primary determinants of biodiversity, the role of biodiversity in ecosystem function and processes, the importance of functional redundancy important, the appropriate mix of species, and any upper or lower bounds to biodiversity.

A Physical Process—Biological Response Model for Spawning Habitat Formation for the Endangered Colorado Squawfish, Yampa River, Colorado

M. D. Harvey[1], R. A. Mussetter[1], and E. J. Wick[2], presented by Karin J. Fisher[1]
[1] Resource Consultants & Engineers, Inc.; [2] National Park Service
Fort Collins, Colorado

The Colorado squawfish (*Ptychocheilus lucius*) a Federally-listed endangered species, spawns at a limited number of sites within the lower Yampa River, Colorado, during the recessional limb of the annual snowmelt hydrograph. A multidisciplinary data collection program at a known Colorado squawfish spawning site in the lower Yampa Canyon enabled the development of a physical process-biological response model for Colorado squawfish spawning habitat.

This model for spawning habitat formation was developed from field measurements, hydraulic modeling (HEC-2), and analysis of a known spawning bar at River Mile 16.5 (Cleopatra's Couch). The process-response model indicates that high discharges are responsible for the construction of the spawning bar but not the actual formation of the spawning habitat. Downstream hydraulic controls cause a backwater condition that results in formation of the bar as a heterogeneous mass of sediments. Reduced tailwater during recessional flows causes a steepening of the local hydraulic gradient which in turn leads to bar dissection and erosion of chute channels. Dissection of the bar causes the fines to be flushed and this is enhanced by reduced sediment delivery from upstream due to deposition in the upstream pool. A clean cobble substrate, with the constituent cobbles near incipient motion and suitable for egg adhesion, is formed in the subaqueous bars that are located within the chute channels. Habitat at this spawning bar is formed at discharges between about 400 cfs and 5,000 cfs. The physical process-biological response model appears to be validated by fish-capture data at this and one other spawning bar in the lower Yampa River.

Similar multidisciplinary investigations could be used to develop physical process-biological response models for habitat formation for all life stages of the threatened and endangered species of the Colorado River Basin. The results of such investigations would provide a scientifically supportable basis for identifying important physical habitat for the affected species.

5 Integrated Resource Management

Earth Resources Stewardship at DoD Installations

Lawson M. Smith
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Vicksburg, Mississippi

During the first two days of the Legacy Earth Resources Workshop, presentations have focused on the nature and occurrence of earth resources on DoD installations and the significance of integrating earth resources information into biological and cultural resources management. While these presentations cover a variety of projects and topics in earth and integrated resources management, the program does not represent the full spectrum of DoD earth resources projects and topics which could be discussed. A broader discussion of earth resource management is presented in the report of the Earth Resources Task Area (ERTA) of the Legacy Resources Management Program. One of the goals of the workshop is to briefly discuss the results and recommendations of the ERTA stated in the March 1993 draft report.

The legislative purposes of the ERTA were: 1) to establish a strategy, plan, and priority list for identifying and managing all significant geophysical (earth) resources, and 2) to establish a standard DoD methodology for the collection, storage, and retrieval of all geophysical information. The ERTA approached these two purposes through the discussion of the identification, description, inventory, analysis, and use of earth resources information in earth, cultural, and biological resources management and installation planning. The ERTA report concludes with recommendations for the use of earth resources information in integrated resources stewardship.

The final goal of the workshop is to get input from DoD installation and headquarters staff on the current and future issues and opportunities in earth resources stewardship. Workshop participants will be divided into five working groups. The groups will use a structured procedure to

identify and briefly discuss their ideas of earth resources stewardship issues and opportunities in DoD. The groups will then be brought together for a summation of the results of the working groups. The issues and opportunities identified by the workshop participants will be incorporated into the final report and recommendations of the Legacy Earth Resources Task Area.

Viewpoint from a Master Planner

Vern Shankle
Picatinny Arsenal
Picatinny, New Jersey

Picatinny Arsenal is a small installation of 6,491 acres having a length of about eight miles and an average width of approximately one and one-half miles. It is bounded on two sides by ridge lines, and use of land is restricted by its current use, steep topography, wetlands, lakes, and explosion zones. Most structures on the installation have undergone adaptive re-use and have been used much longer than their intended lifespan. Earlier, information necessary for master planning was difficult to obtain, it was generally not shared between departments on the installation, and data collection required considerable time. Three years ago, the installation purchased a Geographic Information System (GIS) and it is changing the way we do business. Alliances are being formed between users and data are being shared. The planners are not responsible for the collection of information in the system; however, we rely heavily on the data. Master planners are learning about the Legacy Resource Management Program in their efforts to maintain and restore installation infrastructure in the face of reduced budgets and increased environmental and safety concerns. In order to focus our resources, Picatinny has recently entered into an agreement with the Waterways Experiment Station to develop a digital database and GIS for the installation. This system will integrate cultural, archaeological, biological, environmental, and engineering data and it is expected to enhance resource stewardship and sustainability of the installation.

Dolet Hills Lignite Mine—Land Reclamation and Stewardship

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Central Louisiana Electric Company, Inc.
Mansfield, Louisiana

The Dolet Hills Lignite Mine is located in southeastern DeSoto Parish, Louisiana, approximately 35 miles south of Barksdale Air Force Base. This surface mine produces approximately 2,650,000 tons of lignite, a low rank coal, to provide fuel for the Dolet Hills Power Plant Unit No. 1. This

mine-mouth, 650 megawatt electric generating plant is owned by Central Louisiana Electric Company, Inc (CLECO), Southwestern Electric Power Company (SWEPCO), Northeastern Electric Power Cooperative (NTEC) and Oklahoma Municipal Power Authority (OMPA). Mining operations are conducted by the Dolet Hills Mining Venture, a joint venture partnership of the Costain Group, PLC and the Jones Group, contract mine operator on behalf of CLECO and SWEPCO.

The Louisiana Office of Conservation (LOC) issued the LSM-3 mine permit to CLECO and SWEPCO as Permittee in August, 1983. This permit was issued for a 42 year life-of-mine operation and included 29,500 acres. Surface mining rights on these lands, which are owned by over 1,000 private and corporate landowners, were negotiated and obtained by CLECO and SWEPCO. Prior to submittal of an application requesting the approval and issuance of the mine permit, CLECO and SWEPCO conducted extensive onsite environmental impact investigations of the proposed mine permit and surrounding area. These investigations included geological studies to define the location and quality of the lignite reserves, surface and groundwater hydrology studies, geotechnical engineering, cemetery surveys, etc., biological resources including endangered species, and potential habitat for such species, botanical survey, etc. The mine permit was approved after extensive review by Federal and state agencies including U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, U.S. Soil Conservation Service, U.S. Fish and Wildlife Service, Louisiana Department of Wildlife and Fisheries, LOC, and numerous other state agencies such as Department of Environmental Quality, etc.

The surface mining operations to mine and remove lignite disturb approximately 350 to 400 acres of land annual'. Prior to disturbing the land all obstacles to mining such as oil and gas wells, public roads, dwellings, timber, etc. must be removed and/or relocated. After the lignite is removed the land is regraded and the surface is returned to its approximate original contour. Warm or cool season grass vegetation is planted to control erosion on these recently regraded lands. Once grass vegetation is successfully established, the mined lands are reforested in loblolly pine seedlings. After a five-year Extended Responsibility Period, which includes monitoring by LOC, the lands are inspected by LOC and OSMRE. If the reclamation and reforestation meets federal and state requirements, final performance bond release is approved and the reclaimed lands are returned to the landowners.

6 Resource Management at Eglin AFB

A Geographic Information System for Eglin AFB

Doug Smith, Jackson Guard, Eglin Air Force Base, Florida

Gary Hennington, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

The Geographic Information System (GIS) of Eglin AFB is in an early implementation phase. Hardware and software have been purchased and an employee has been trained and dedicated to the project. Presently, data input is populating the GIS. The demo on display in the lobby of the workshop location allows an overview of the data layers in the GIS. As an example, problems encountered in expanding clay pits are provided. The clay pit expansion is limited to areas of geologic clay prospects, and constrained by red-cockaded woodpecker (RCW) and Okaloosa darter habitats and areas having cultural resource potential. Using the GIS, boundaries can be placed around RCW sites which have a good geologic potential for clay production. RCW sites require additional surveys to determine adequate forage requirements. The GIS can then be queried concerning areas of low cultural resource potential located inside these boundaries. Utilizing these types of information clay pit expansion can be done with intelligent integrated stewardship. The GIS of Eglin AFB will later grow to include additional earth, cultural, and biological resources management information.

Landscape Restoration and Ecosystem Management

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Restoration and maintenance of native biological diversity and sustainable human use of resources have been identified as important endpoints of ecosystem management at Eglin AFB. The science of restoration is goal-oriented. The goal or endpoint of restoration generally is to repair or reassemble a landscape such that it resembles a model, either derived or based on extant examples. Landscapes consist of diverse linkages among abiotic and biotic elements; history is important, as are spatio-temporal relationships. Elements of landscape restoration include, in increasing order of complexity, physiognomy, productivity, native flora and fauna, native communities and ecosystems, and ecosystem processes. In order to achieve their restoration goals, Eglin managers require a better understanding of how the landscape is put together and how it behaves. From both a scientific and management perspective, this poses a number of challenges, not the least of which are the questions: Of all the elements (species, processes, structure, etc.) that comprise a landscape, which ones are likely to be most important? How do managers monitor the impacts of management and progress toward goals? Ecological theory and scientific process offer some ways of narrowing the choices. For this reason, a large-scale and long-term scientific management strategy is being designed on Eglin AFB. A fundamental challenge of managers, at Eglin and elsewhere, is to ensure that limited research dollars are used to answer not only practical questions of management, but also to yield insights relating to broader questions. Interdisciplinary ecological modeling, in concert with carefully planned, integrated, and management-related field research, may well increase the likelihood that research will yield broadly useful information. Early participation by earth scientists will be critical to the success of the program, as will be the integration of on-going and proposed research into the broader scientific effort.

Ecological Research on the Endangered Okaloosa Darter

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Gainesville, Florida

Our research on the Okaloosa darter, *Etheostoma okaloosae*, focuses on distribution, reproductive biology, and microhabitat ecology. In order to analyze distribution patterns, we collected distributional data from all

logical and esoteric sources known to us, and organized the records geographically and chronologically. These data document the rate of replacement of the Okaloosa darter by the nonindigenous brown darter, *E. edwini*, and further suggest a fluctuating zone of sympatry exists between the two darters in the Rocky Creek system. Preliminary salinity tolerance studies indicate the brown darter is able to tolerate salinity up to 15 ppt for short periods of time. This physiological tolerance offers a heretofore unanticipated dispersal mechanism around Rocky Bayou, a saline bayou in the lower Choctawhatchee River drainage. The Okaloosa darter spawns in fine-stemmed macrophytes in running currents. The Okaloosa darter belongs to the egg attaching guild of darters wherein females typically attach eggs to the stems or leaves of submergent macrophytes. Social behavior appears relatively complex and includes deceptive behavior (sneaker males) in order to gain access to receptive females. Spawning in the wild by the brown darter has not been observed, but laboratory studies suggest the brown darter may utilize a different habitat for spawning. The brown darter is also an egg attacher. In our microhabitat research, we are attempting to determine if the darters utilize the same microhabitat in the Rocky Creek system. We are examining microhabitat variables in allopatric and sympatric populations of Okaloosa and brown darters, and will analyze data for overlap and for shifts in microhabitat variables in areas of sympatry. Other field and laboratory experiments will be conducted as new insights are gleaned from field work.

Geomorphic Controls of Darter Habitats

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The Okaloosa darter (*Etheostoma okaloosae*) is endemic to several drainages on Eglin Air Force Base near Niceville, Florida. The two largest watersheds in which the darter is found are Turkey Creek and Rocky Creek. Over the last 20 years or so, Okaloosa darter populations in the Rocky Creek drainage have been replaced by populations of the brown darter (*Etheostoma edwini*), which was accidentally introduced to the area. The brown darter populations have spread up the Rocky Creek drainage to a specific area, upstream of which brown darters are absent, with the exception of a single 1975 sample site. The reason for this limited expansion is unknown. A primary objective of this study is to determine the hydrologic, geomorphic, and hydraulic characteristics of Okaloosa and brown darter habitat, to determine present population distributions, predict future expansion of the brown darter, and to identify potential methods of stabilizing and increasing Okaloosa darter populations. Historic maps and hydrologic data are being utilized in conjunction with recently collected field data including slope, velocity, and substrate measurements to determine the physical characteristics of darter habitat. The effects of man-induced changes such as clay pit development, road crossings, culvert construction,

and reduced burn frequency are being considered as possible causes for historic habitat modification which may relate to present species distributions.

Proactive Cultural Resource Management

Newell Wright
Eglin Air Force Base, Florida

Eglin Air Force base is responsible for identifying and protecting cultural resources on approximately one-half million acres. Early cultural resource studies began in the 1920's, with additional work during the 1930's and 1940's. Detailed, modern cultural resource evaluations have been conducted over the last ten years. Human activity is evident just behind the beaches where there are shell accumulations indicating dietary habits of prehistoric humans, there is the wreckage of a World War II V-2 tested here, and the remains of bunkers where the testers viewed the tests. Inland, in the pine uplands, just below a clay pit, there are remains of a burn pit, with older materials below it, where, 2,000 to 3,000 years ago early humans inhabited shores of an ancient lagoon. Radiocarbon data from the Yellow River and other drainages indicate that sometime after 8,000 years ago, the modern pine dominated forest was established. Before that time, the forests were oak dominated. Pine forests do not offer as many resources for humans; thus, this shows there would have been less human occupation when the forests changed to pine dominated. Data from known cultural sites plus other environmental data have been used to construct a model for locating potential cultural sites. This model is used to assist planners to determine the impact of construction and mission activities on cultural resources in a given area. Even with the model, there are large areas where we are unsure of the locations of cultural resources; however, we feel that in these areas, the potential is low. We believe that our stewardship of cultural resources are well-integrated with mission requirements, and we are working closely with Native American and other groups to that end.

Integrated Resources

Jesse O. Borthwick
Eglin Air Force Base, Florida

This presentation describes the Air Force Development Test Center's (AFDTC) approach to environmental planning with special attention given to range resource management. The evolution of Eglin's Environmental Impact Analysis Process (EIAP) is described along with a description of problems encountered in accessing a multitude of environmental constraint data, considering cumulative impacts, and memorializing decisions. AFDTC's strategic plan which calls for the development of a Geographic Information

System (GIS) and Programmatic Environmental Impact Statement. EIAP started in the 1970's, and any actions proposed at Eglin must go through the EIAP process. If we cannot arrive at a Finding of No Significant Impact, we must go through an Environmental Impact Statement (EIS). Lately, we have had an increased number of requirements for EIS's; these take approximately four to six months.

In regard to NEPA, our customers at Eglin are often unaware of requirements and timelines, environmental issues are not considered early enough, compliance or mitigation monitoring is limited, and the cumulative effects of activities are not adequately addressed. We are developing programs to increase customer awareness, to monitor NEPA activities, and to make the EIS more programmatic. The potential risk is high when the Categorical Exclusion provision is misused. An EIS with finding of No Significant Impact, which takes six to twelve months, risks decrease. An EIS with a Record of Decision, which takes 10 to 12 months, the risk is minimal. One must balance time versus the risk factors. The programmatic EIS, which will take approximately three years, will: define existing environments, define scope of RDT&E missions, identify environmental restraints, identify impacts, design mitigations, and coordinate with public and regulatory agencies.

The payoff from the programmatic EIS will be early assistance to our customers through early definition of environmental requirements—it will ensure compliance with NEPA and other laws, it will prevent contamination and subsequent cleanup costs and lengthy delays in program execution, and it will establish AFDTC as the environmental leader. It will also attract future customers to the base. An important aspect of our program is the establishment of our geographic information system.

Coordination and Decentralization of Geographic Information Systems

Ken Bristol
Eglin Air Force Base, Florida

As the Services go through the downsizing process, Geographic Information Systems (GIS) are the essential tool installations are using to collect, manage, and analyze the dynamic wealth of information that environmental concerns must address. The system at Eglin has been operational for three years. From Headquarter to Base level, the development of these systems needs to be coordinated while remaining decentralized. The GIS is not a separate entity, it is a tool to bring a large amount of data together and it empowers stewards to make the right decisions. The difference between a GIS and CAD is the ability to query the GIS database and obtain a map representation of various aspects of the data. The GIS handles geographic data through input, data management, manipulation and analysis, and output. The diversity of information stored in the GIS and the diversity

of interests among the users requires close coordination and cooperation among the users and customers. Here at Eglin, we have formed a task group to coordinate our efforts and address system architecture, mechanical aspects of system usage, facility management, natural resources, and emergency management. We are pooling our resources, and we are approaching system development as an integrated team. Our task group is striving for compliance, mission support, and environmental excellence.

7 Earth Resources Field Trip

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As a part of the workshop, participants had the opportunity to attend a one-half day field trip which highlighted and supplemented the formal presentations and which showcased the diversity of biological and geological environments and resource issues at Eglin AFB. Figure 1 is a map of Eglin AFB showing field trip stops. The purposes of the field trip were:

a. To demonstrate the earth resources of Eglin AFB as they relate to natural and cultural resource management.

b. To develop an understanding of earth resource processes and data in terms of integrated resource management.

c. To describe the ERTA demonstration project addressing the geomorphic controls on the habitat of the endangered Okaloosa Darter.

d. To illustrate the environmental and operational issues pertaining to management of clay pits on the base.

At Stop 1, State Route 85 bridge over Juniper Creek, participants were shown a stream gaging station and they received an explanation of the significance of hydrologic data in understanding the habitats of riparian fauna (Figure 2). Stream gage data are necessary to describe the energy conditions of streams and the relations between stream flow, stage and the condition of the channel. Stop 2 on Turkey Creek represented a typical, high gradient Okaloosa stream in which one could observe the bed and bank-line conditions, riparian and channel vegetation, and typical fluvial habitats occurring in this system.

Stop 3 was located at Parish Branch and it provided access to a near-by steep head and clay borrow pit. The term "steep head" is derived from the fact that these features occur at the head of stream valleys and they occur as steep, deep canyons upon upland surfaces (Figure 3). Steep heads are unique landforms of the Florida Panhandle having rather distinct floral

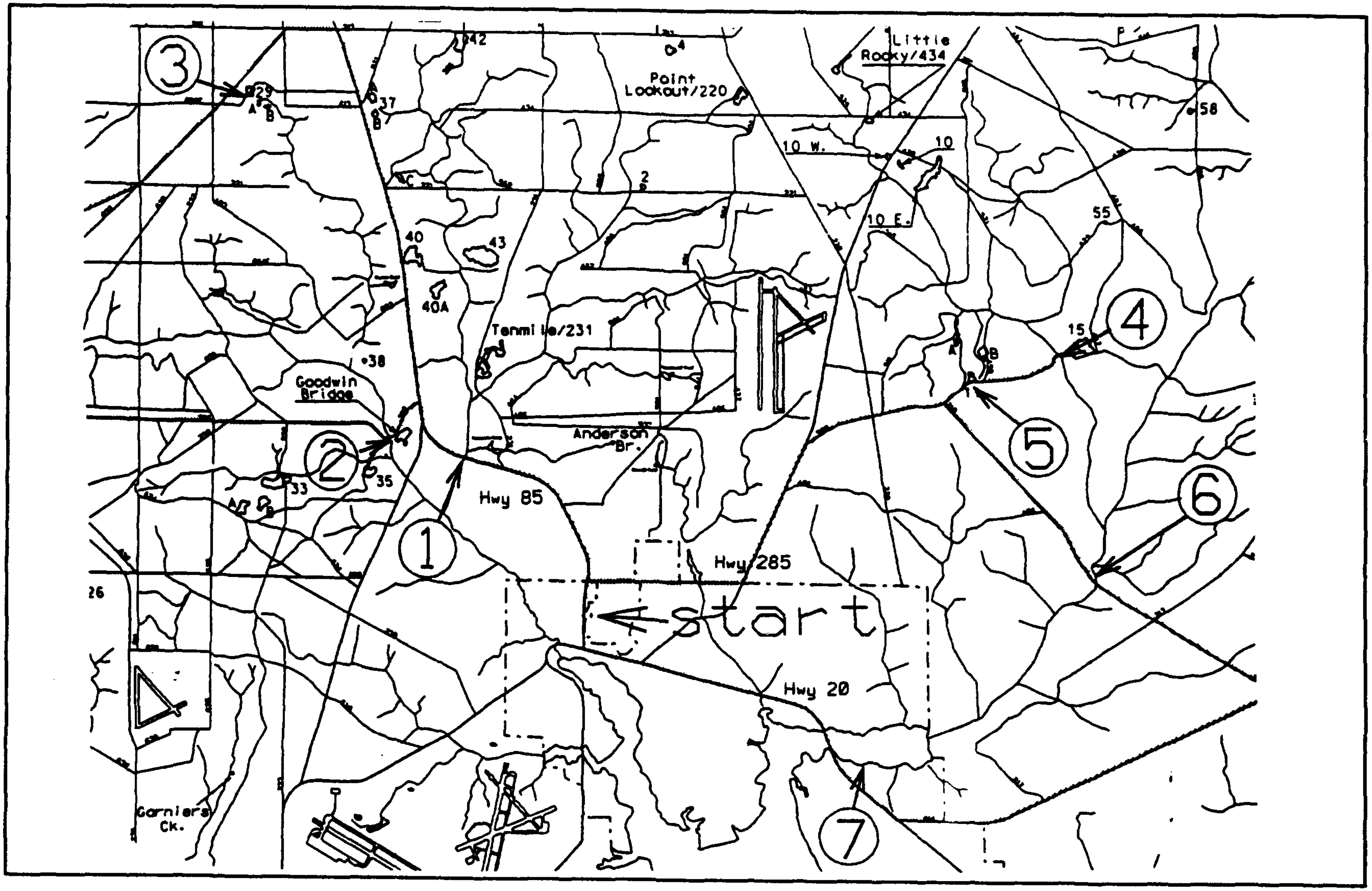

Figure 1. Map of portion of Eglin AFB showing the locations of field trip stops

Figure 2. Field trip Stop 1 at State Road 85 crossing of Juniper Creek. Paul Albertson (WES) and Karin Fisher (RCE), center on platform, are explaining stream gage data collection and analysis

Figure 3. View of a steep head at Stop 3

habitats and they are the sources of a number of the darter streams. Groundwater seeps to the surface at the steep head providing water to the streams flowing away from the steep sandy face of these features.

Stop 4 at Little Rocky Creek was in a reach of the creek inhabited by both the endangered Okaloosa darter and the brown darter. Populations studies have shown that the brown darter has, over the years, extended its habitat further upstream into reaches formerly inhabitated by the Okaloosas. A Legacy Earth Resource demonstration project is currently underway at Eglin to investigate the influence of geomorphology on darter habitats. These studies are intended to explain the occurrence of Okaloosa versus brown darters in terms of stream flow regime and channel bed and bank conditions along Little Rocky Creek and other streams in the area.

Stop 5 was at an active clay pit and one which is intended to be enlarged (Figure 4). Generally, most of the base is underlain by non-lithified Quaternary sands and gravelly sands. Clayey material is rather limited; however, such material is an important resource which is required for road surfacing and other applications. The occurrence of clayey material is usually limited to thin, near-surface weathered zones in the sands and gravelly sands. There are approximately 160 pits on the base which have been operated at one time or another as sources of clay or borrow material. These pits are subject to erosion by surface runoff and the closure of abandoned pits is an important environmental issue being addressed by resource managers. Furthermore, besides erosion, pit operation as well as pit closure must address the effects of mining or closure operations on floral and faunal habits and cultural sites at or near the pit. The enlargement and extension of clay pits involves considerations similar to the ones described for pit closure.

Figure 4. View of Stop 5, an active clay pit and a source of road construction materials

Stop 6 at Big Rocky Creek was a typical, low gradient stream reach inhabited by brown darters. At this stop, participants were able to observe the channel bed and bank conditions of this brown darter stream and compare them with conditions at Stop 4 on Little Rocky Creek inhabited by both darters. Generally, conditions appeared similar and one would presume that specific darter habitats were controlled by details of the flow regime which could not be identified from visual field data.

The last stop of the field trip was Stop 7 at Fred Gannon State Park bordering on Rocky Bayou, an estuary inhabited by brown darters (Figure 5). Rocky Bayou is the mouth of Rocky Creek and it is an example of a fringe (marsh) wetland ecosystem. The management and protection of wetlands is an another important resource management function at Eglin where, besides fringe wetlands, there are riparian, slope, and depressional wetland types.

Figure 5. View of Stop 7, Rocky Bayou, a fringe wetland system and mouth of Rock Creek

8 Issues and Opportunities

The final phase of the workshop was devoted to group work sessions. The attendees were divided into five work groups chaired by Legacy personnel and each group was tasked with identifying the most significant issues and opportunities facing the ERTA, LRMP, and DoD in general (Figure 6). The principal issues identified can be related to either command support, information management, training and education, or integrated resource management. For each of these general issues, there were a number of challenges. Many of the specific challenges listed below do not occur at every DoD installation. Some DoD installations have developed outstanding programs that offer solutions to some of the challenges listed. Also, there are a number of significant opportunities before DoD which, when taken, will provide substantial progress to the ultimate achievement of earth resources stewardship. The opportunities are categorized in terms of the principal issues. The issues and opportunities discussed in

Figure 6. Workshop participants developing LRMP "issues" and "opportunities"

this section will be the basis for the development of a strategic plan which will be the subject of a future ERTA report.

Issues

Issue: Command Support for Earth Resources Stewardship

Command support is critical to all activities in DoD, especially complex long-term programs like the stewardship of earth resources. Active aggressive programs that go beyond compliance and fundamental management require the entire command/management chain to embrace the concepts of stewardship as a fundamental part of the fulfillment of the mission of the installation. Despite the substantial growth in aggressive earth resources management in DoD over the last few years, a number of problems still exist which are related to command support.

Insufficient understanding of earth resources stewardship concepts by commanders and managers. Many senior commanders and managers do not understand the fundamental process of earth or integrated resource stewardship. In fact, many of the senior managers and commanders may not fully understand the regulatory and policy basis for earth resources management. Earth resources issues may be viewed as "academic" and not critical to the mainstream of "natural resources management." Additionally, some earth resources management initiatives are seen as negatively impacting the mission of the installation.

Low priority of funding for earth resources management activities. Most of the funding in natural resources management goes to biological resources management projects such as wildlife and fisheries, timber management, and threatened and endangered plants and animals. Although, these programs are vital, may be necessary for compliance, and are often revenue producing themselves, little funding is left to address the management of the earth resources which strongly influence or control the distribution and character of these biological resources.

Lack of perceived importance of earth resources information. Earth resource information is often viewed by other resource managers, planners, and facilities engineers as "nice to have, but not critical." These individuals typically have little training in earth science and limited experience in working with earth resources information.

Lack of influence of earth resources managers. Many earth (and cultural and natural) resources specialists at DoD installations feel that insufficient consideration is given to their recommendations in the development of long-term plans and programs for the installations. For integrated resources stewardship to be achieved, the knowledge, experience, and

recommendations of earth resources specialists must be sought and supported throughout the command/management chain.

Little or no sense of responsibility for earth resources management or stewardship at all levels. In some instances at DoD installations, the responsibility for earth resources management is poorly defined. This is particularly true for those installations that have small staffs or are relatively small in size.

Earth Resources management initiatives are not integrated with the mission. When earth resources management initiatives do occur at some installations, inadequate time or resources may be given to coordination of the initiative with missions. Sometimes this lack of coordination can result in adversarial relationships between offices. Adverse impacts on missions within responsible resource stewardship should be a principle objective of resource managers.

Failure to implement the recommendations of earth resources studies into integrated resource stewardship. In some instances, valuable earth resources information has been developed for installations with recommendations on how and when the information may be used to support missions and requirements. For various reasons, these recommendations may go unheeded in the development of resource management programs, installation plans, training decisions, and facility engineering.

Issue: Information Management

Integrated earth resources stewardship requires the acquisition and use of a wide variety of information. Many of the problems which must be overcome to achieve earth resources stewardship are related to information management procedures and policies.

Lack of standard methods for earth resources stewardship. There is generally a widespread and significant lack of specific knowledge of earth resources stewardship concepts, requirements, methods, and goals in DoD. One of the mandates of the LRMP is to develop "standard methods" for management of earth resources. Standard methods of management should result in standard data and information types, significantly reducing the cost of data acquisition and confusion of data use.

Lack of available information and data on earth resources. For most earth resources at DoD installations, there is insufficient information on the character and distribution of the resource to enable management of the resource.

Inadequate information transfer between all offices. In some instances, detailed earth resources information has been acquired for such activities as an environmental impact statement, special project, installation restoration, cultural resources survey, or engineering evaluation. Un-

fortunately, the information remains in the office that developed the information and does not get to other offices that need the information to complete their function.

Inconsistencies and incompatibilities of data management. As stated in the problem of information transfer between offices, significant amounts of earth resources data in various forms and formats may have been developed for a variety of uses at an installation. Frequently, the use of data by several different offices is complicated by inconsistencies in the ways in which the data were acquired and\or stored. An example is the development of digital data bases in a particular GIS in use in the installation planning office that is incompatible with the GIS in use in the environmental office.

Little public awareness of DoD earth resources and management initiatives. The DoD is blessed with a variety of valuable earth resources that go largely unrecognized by the public. Additionally, there are some excellent examples of earth resources management in DoD whose stories need to be told.

Issue: Training and Education

Training and education in earth resources is key to the achievement of the goals of this plan. A general lack of knowledge of earth science and the significance of *earth resources information* in many DoD activities is the greatest impediment to achieving integrated earth resources stewardship on DoD installations.

Not enough trained earth resources managers in DoD. Most earth resources management in DoD is presently being accomplished by natural resources staff trained in biological sciences. There are some notable exceptions at a few installations where earth scientists have made a significant impact on natural resources management that includes earth resources. Particularly exceptional are a group of natural resource managers who have been trained as physical geographers and who have a broad based and specific academic backgrounds that include geology, soils, climate and meteorology, natural resources management, and remote sensing, and GIS.

False expectations about existing earth resources information. The DoD has profited significantly from partnerships with other Federal agencies in the acquisition of earth resources information. This is particularly true when earth resources investigations have been conducted specifically for the installation. There often are, unfortunately, false expectations about the use of existing (often regional in scope) earth resources information in installation management activities. For instance, regional geologic and hydrologic maps are of insufficient resolution to be of use to many resource management or environmental analysis projects at locations on an installation. The installation user is often without a background in

earth science and without knowledge of how and why the maps were made and their intended use. The user incorrectly assumes that adequate earth resources information has been incorporated into the activity, when in fact, the earth resources data provide limited insight into the problem.

Lack of fundamental cross-training in earth sciences for natural and cultural resources managers. Many cultural and natural resource managers have limited formal training in earth science and are unfamiliar with benefits of integrating cultural, biological, and earth resources management initiatives or the requirements of earth resources management.

Lack of knowledge of mission, goals, responsibilities, and expertise of potential partners. There are a significant number of potential partners in DoD resource management who may contribute valuable information. However, in many instances, this information is not being exploited because DoD resource managers do not know that the information is available or which agency is responsible for developing the information.

Issue: Integration of Cultural, Biological, and Earth Resources Stewardship

Existing earth resources management activities are often fragmented. As briefly described above, DoD presently manages it's earth resources in a variety of ways for many reasons. Earth resources management is included in facilities engineering (soil, water, construction materials), installation restoration (soil and water), natural resources management (soil, water, wetlands) and installation planning (primarily resource identification). These efforts are often conducted by different installation offices with different funding sources for different reasons. The information is frequently not stored in a system which is accessible to all who have need of the information. In fact, in some cases, many of these offices are unaware of the earth resources management activities being conducted at other offices at the same installation. Unfortunately, the problem of fragmentation of earth resources management exists at all levels of DoD.

Biological and cultural resource management does not always include earth resources information. Many biological and cultural resource managers do not understand the significance of earth resources information in the identification, evaluation, and management of their resources. Significant progress has been made in the last decade in the use of earth resources information in cultural resource management. However, the integration of earth and biological resources management has, in most instances, only considered the most obvious relationships in a general and subjective manner. Earth resources information is sometimes considered as "nice to have" but not critical to resource management. Many cultural and natural resource managers also consider the acquisition and use of earth resources information as expensive and time consuming. Consequently, some programs of biological and cultural resources management at DoD installations are based on inadequate information to fully achieve their goals.

Lack of long-term integrated resource stewardship program. Many installations have cultural and natural resources management plans that may briefly discuss some earth resources. Plans to achieve integrated resource stewardship generally do not exist because the concepts and processes of integrated stewardship are poorly understood by installation staff.

Opportunities

Command Support

Resource management will be enhanced when commanders and managers are aware of the importance of integrated resource management and how successful management will support, rather than hinder, the installation mission. Commanders and managers may need to be educated in these areas, and this must be done by resource managers who understand mission requirements as well as the requirements for compliance and stewardship. Resource management should be conducted by a bottom-up approach. Since resource management is fundamentally interdisciplinary, there may be a need to make personnel positions interdisciplinary. Commanders and managers will significantly enhance resource stewardship by establishing or configuring organizational units which combine rather than fragment earth, biological, and cultural resource activities. At higher echelons of command, consideration should be given to the consolidation of funding sources and requirements for these activities.

Information Management

Enhanced communication and information transfer will occur through shared information systems and data dictionaries. For this to occur, installations must develop complete resource databases, and maintain this information on a multi-user, multi-function, installation-wide GIS. Partnerships should be formed with state and Federal agencies and academic institutions having databases and other forms of data in order to capitalize on existing systems and expertise in specific areas of earth science.

Training and Education

Resource managers should ensure that their personnel are cross-trained in or at least knowledgeable of the role of earth resources in natural and cultural resource management and its role in installation mission. Short courses, seminars, and related educational activities are vehicles for this kind of professional development. Commanders, managers, and resource management personnel should also become familiar with the laws, regulations, and guidelines pertaining to earth resources. The general public should be made

aware of resource management initiatives through brochures, pamphlets, and special purpose programs for hunters, fishermen, and nature enthusiasts.

Integrated Resource Management

Commanders and resource managers should ensure that earth resources are considered and integrated into installation mission, engineering projects, environmental restoration, as well as biological and cultural resource activities. Particular attention should be given to integrating data derived from engineering and environmental restoration projects.

9 Summary, Conclusions, and Recommendations

Summary

The Earth Resource Workshop was held at Eglin AFB during a three-day period in March 1993. The workshop was attended by approximately 50 individuals having backgrounds in natural and cultural resource management and who represented industry, consulting services, Federal and state governments, and academia. The primary objectives of the workshop were to inform resource managers of the relevance of earth resource data to their activities, receive input from the field, identify earth resource issues and solutions, review the ERTA draft report, and develop the basis for a strategic plan for earth resource stewardship. There were 20 presentations which addressed earth, biological, and cultural resource management, integrated resource management, and resource management at Eglin AFB. Participants also attended a one-half day field trip during which they observed and discussed earth resource issues in the field. Working groups were formed in which the attendees had the opportunity to identify and discuss significant resource stewardship issues, challenges, and opportunities facing the DoD.

Conclusions

The presentations addressed most of the important aspects of earth resource stewardship and described procedures and methods for managing earth resources and integrating earth resource data into biological and cultural resource management. Also, the workshop participants recognized the importance of earth resources within the framework of overall installation management, as well as the significance of earth resources in the stewardship of biological and cultural resources. The ERTA received a number of useful comments from the workshop participants on their draft report. It was generally realized that workshops such as this one were beneficial to resource practitioners and managers alike, and that similar workshops should be conducted at other major DoD installations in the future.

In the discussion sessions, the participants considered that command support, information management, training and education, and integrated resource management were the most important issues facing the DoD in its efforts to enhance resource management at its installations.

Recommendations

The following recommendations are based upon information from the workshop presentations, the experience and ideas of the workshop participants, and the findings of the ERTA team:

a. Commanders must be made aware of the importance of earth resources and earth resource data in their relation to installation mission as well as to the solution of environmental issues. Commanders and managers should also ensure that natural and cultural resource activities and their management are not fragmented.

b. Earth, biological, and cultural resource data should be in GIS databases available to and compatible with systems in resource management, facility engineering, planning, and other organizational units on the installation. Installations should also maintain partnerships with other Federal, local, and state agencies and with academic institutions having earth resource functions.

c. DoD personnel involved in the management and practice of resource management should receive further training and cross-training in the applications of earth resource data to the solution of natural and cultural resource issues.

d. Resource management activities must be integrated. Managers should ensure that biological and cultural resource investigations, surveys, etc., include consideration of the impact of earth resource data on the biological or cultural resource issue.

Appendix A
Biographies of Speakers

Paul Albertson is a graduate of East Carolina University, earning a BS in 1977. Since 1978, he has worked for the U.S. Army Corps of Engineers. He served six years as a field geologist for the Nashville District. For the Vicksburg District, he was a Project Geologist for the Red River Waterway. Working at the U.S. Army Engineer Waterways Experiment Station (WES) since 1990, his interests are groundwater, geomorphic mapping, geo-archaeology and GIS applications. He has published over twenty articles on these subjects. He has done graduate work in Engineering Geology at Texas A&M. Paul joined the Legacy Earth Resources Task Area Team last year. He is a coauthor of the Legacy Earth Resources Report, and the workshop's coordinator and field trip leader. Previously, Mr. Albertson has led field trips for kindergarten, grade school, and college students. Professionally, he has also guided trips for Association of Engineering Geologists and American Association of Petroleum Geologists.

Ken Bristol is an Information Systems Forester in the Natural Resources Branch at Eglin Air Force Base, Florida. He has worked as a Procurement Forester for Champion International's Timberland Division and as a Senior Party Chief for a land surveying firm prior to coming to the Natural Resources Branch in 1989. He holds a B.S. in Forestry from Stephen F. Austin State University.

Jesse O. Borthwick currently serves as the Chief of Environmental Planning for Eglin Air Force Base where he has been employed as an Environmental Engineer since 1985. He holds an A.A. Degree in General Science from Okaloosa-Walton Community College, a B.S. Degree in Marine Biology from the University of West Florida, and two Master's Degrees from Penn State University, one in Environmental Engineering and the other in Acoustics. He began his career as an Environmental Specialist with the Florida Department of Transportation in 1971. From 1973 to 1978 he worked with the Florida Department of Environmental Regulation (FDER) in their headquarters in Tallahassee. In 1978 he left state government to become the Executive Director of a national environmental organization. He returned to FDER in 1983, working as Special Assistant to the District Manager in Pensacola until 1985 when he became employed at

Eglin. He is a founding member and Charter Chairman of the Major Range and Test Facility Base (MRTFB) Environmental Coordinating Committee (MECC) a standing committee chartered by the Defense Environmental Policy Council (DEPC). The MECC consists of representatives of six ranges and serves to promote strategic environmental planning, encourage R&D initiatives related to the MRTFB mission, and foster crossfeed among all 22 MRTFB member ranges. Collectively, these ranges represent approximately 52 percent of CONUS DoD lands and cover the full spectrum of environmental issues.

Noel Burkhead is employed as a Fisheries Biologist/Research at the National Fisheries Research Center, Gainesville, Florida. Noel has studied southern Appalachian and southeastern nongame freshwater fishes since 1970 in the areas of ecology, behavior, distribution, conservation, and systematics. He holds a B.S. in Biology and a M.S. in Zoology. His entire work experience has been centered in pure and applied research, primarily on fishes in the families Cyprinidae, Ictaluridae, and Percidae. He has studied the endangered Okaloosa darter since 1988, with emphasis on analysis of distribution patterns, comparative reproductive behavior of the okaloosa and brown darters, and identification of limiting factors. Present research emphasis is on comparative microhabitat ecology of Okaloosa and brown darters.

Robert Dunn, Senior Archeologist for the U.S, Army Engineer District, Little Rock (LRD), serves in the Environmental Analysis Branch, *Planning Division.* He is responsible for LRD's Cultural Resources Management (CRM) Program and also serves as a Project Manager in Planning Division. He provides technical support to military installations in Arkansas in the area of archeology and historic preservation. Since 1986, he has worked to establish CRM programs at Fort Chaffee and Pine Bluff Arsenal using geomorphology and geoarchaeology to identify and manage archeological sites. In 1992 he completed a two-year Leadership Development Program at LRD and the Army Management Engineering College in Rock Island, Illinois. He holds an M.A. (Archaeology) from Temple University and a B.A. (Anthropology) from the University of Pennsylvania and completed an internship in Archaeology in 1982 at the Illinois State Museum. Prior to joining the Corps of Engineers at Rock Island, Illinois, in 1983, he worked as an archeological contractor in Wyoming.

Karin J. Fischer is employed as a Senior Geomorphologist at Resource Consultants and Engineers (RCE), Inc. Karin obtained her M.S. degree in geology from the University of Wyoming in 1986. Her experience at RCE consists primarily of quantitative geomorphic analyses of river systems. She has conducted geomorphic investigations of several different types of river systems, and produced results which have subsequently been incorporated into river engineering and resource management strategies. Recently, she has developed a bank protection alternatives scheme for the Feather, Bear, Yuba, and American Rivers, which integrates river geomorphology with engineering requirements and environmental concerns. Other recent projects include geomorphic investigations of streams of the Nono Basin,

California, and the Lower Truckee River, Nevada, to aid in the development of fisheries and riparian vegetation restoration strategies. Prior to joining RCE, she worked for the State of Wyoming as a field geologist, and for a private company based in Cairns, Australia, leading epithermal gold exploration crews in northern Queenland, Australia.

David Gillette is State Paleontologist, Utah Division of State History, Salt Lake City, Utah, and he is also a research associate with the Southwest Paleontology Foundation, Inc., Albuquerque, New Mexico. He received a B.S. in biology from Michigan State University in 1967 and a Ph.D. in paleontology from Southern Methodist University in 1974. Previously, he has been on the faculty of Bryn Mawr College (Pennsylvania), Sul Ross State University (Texas), College of Idaho, and Southern Methodist University (Texas), and he has served as the curator of paleontology of the New Mexico Museum of Natural History. He was pre-doctoral research fellow at the Smithsonian Institution, and he is currently a consultant to the Los Alamos National Laboratory (New Mexico). He is the author or co-author of over 100 books, technical papers, abstracts, reviews, and popular articles in magazines dealing with various aspects of paleontology. He has conducted field work at a number of sites in the U.S. and in Argentina, Australia, India, Egypt, and Mexico, as well.

Jeffery L. Hardesty, based at the University of Florida, is Coordinator of the Public Lands Program for the Florida Regional Office of the Nature Conservancy. Jeff holds an M.S. in Wildlife Ecology from the School of Forest Resources and Conservation, University of Florida. He has worked on a wide number of conservation-related issues in the western United States and Florida, principally focusing on endangered species research, long-term monitoring, biodiversity policy and forest management, and biodiversity-related public education.

Gary Hennington is currently under contract to the U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. Mr. Hennington graduated from Louisiana Tech University with a bachelors of science in Electrical Engineering Technology.

John Isaacson received a B.S. in Anthropology from San Francisco State University in 1978. He received his Ph. D. in Anthropology from the University of Illinois in 1987. He completed a two-year post-doctoral research appointment in the Program on Ancient Technologies and Archeological Materials, Material Research Laboratory, University of Illinois. He was the Associate Director of the Gordon McKay Materials Research Laboratory, Harvard University, and is now a Principal Investigator at the U.S. Army Construction Engineering Research Laboratories. Dr. Isaacson has conducted archeological fieldwork in California, the Great Basin, the Midwest, northeastern and southeastern United States, and northern South America.

Charles Klimas is a consulting ecologist based in Seattle, Washington, with ongoing projects throughout the United States. He specializes in the

evaluation, management, and restoration of ecosystems, particularly wetland and riparian areas. He was formerly a Research Ecologist with the Waterways Experiment Station, where he conducted and directed studies nationwide for more than fourteen years. He has participated in the design of a 20,000-acre National Wildlife Refuge in Indiana, a 150-acre endangered species habitat riparian restoration on Camp Pendleton in southern California, a 9,000-acre floodplain reforestation project in Mississippi, a 100-acre Wetland Mitigation Reserve in western Washington, and various other projects. He has field experience in more than 30 states, and his research efforts have ranged from very localized endangered species investigations to a three-year detailed analysis of more than a million acres of forests along the Lower Mississippi River. Dr. Klimas holds graduate degrees in both Forest Ecology and Wildlife Ecology. He is certified as a Senior Ecologist by the Ecological Society of America, and serves as Associate Editor of the journal *Restoration Ecology.*

Anthony Krzysik is a Principal Investigator for the Natural Resources Management Team at the U.S. Army Construction Engineering Research Laboratory, Champaign, Illinois. His research interests are in community/ecosystems ecology, quantitative/statistical ecology, biometrics/experimental design, landscape ecology, and habitat and nongame wildlife management. Research activities have been focused on the development of multivariate models for quantifying: community and habitat structure, wildlife-habitat associations, and environmental assessments and monitoring; and developing and implementing novel strategies for field research and data collection, including experiments with expert systems and voice-recognition technology. A major goal of the research has been to develop strategies for wildlife/habitat enhancement and mitigation, and natural resources management on Army lands, consistent with military training missions. In addition to this ongoing research, research is currently being initiated in: a) heterogeneity and mosaics, and ecosystem/community structure/function as determinants of regional and local patterns of biodiversity, b) interfacing theoretical ecology and conservation biology for optimizing the management of threatened/endangered/sensitive species, and c) the development of practical methodologies of wide applicability for the assessment and monitoring of ecosystem health, and the fate/effects of environmental contaminants. Dr. Krzysik received his B.S. in Chemistry from Carnegie/Mellon University, his M.S. in Chemistry from the University of Pittsburgh, and his Ph.D. in Biology from the University of Pittsburgh. He has extensive experience in a wide variety of environments, but particularly in: desert, forest/woodland, riparian, and aquatic ecosystems.

David M. Patrick is Professor of Geology at the University of Southern Mississippi (USM). He received a B.S. in civil engineering from Purdue University (1962), an A.M. in geology from the University of Missouri (1964), and a Ph.D. in geology from the University of Oklahoma (1972). He has been on the faculty of USM since 1982; prior to USM he has been employed by the Indiana Highway Commission as a testing engineer, and by the Waterways Experiment Station as a geologist. He is a registered professional engineer and geologist engaged in environmental

geology and water resource investigations. He has been associated with the Legacy Resource Management Program since 1991.

Rene Quinones is a Physical Science Technician with Directorate of Public Works, National Training Center, Fort Irwin, California. His responsibilities encompass the areas of geology, hydrology, electronics, energy management, remote sensing, and renewable energy sources. He has received an A.S. in electronics and resource management. Currently, he is working towards his B.S. in management. Current projects include the development of a Geographic Information System for the post, geothermal resource management, and the testing of the Remote Minefield Detection System (REMIDS) on the endangered desert tortoise.

Stanley A. Schumm is a Senior Associate at Resource Consultants & Engineers, Inc. and a University Distinguished Professor at Colorado State University. He received a B.A. in geology from Upsala College in 1950 and a Ph.D. in geomorphology from Columbia University in 1955. He was employed for 12 years by the U.S. Geological Survey as a research geologist. During this time, his main activities involved investigations of erosion rates and erosion problems in the western United States and river morphology and river changes, in the western United States and Australia. Upon joining the faculty of the Department of Earth Resources at Colorado State, he began a program of experimental fluvial geomorphology (drainage network, alluvial fan, river and incised channel development and evolution) and continued research on river variability and river change (Mississippi, Nile, Indus, Great Plains, and Rocky Mountain rivers). Recognition of the significance of the research has resulted in awards from the American Geophysical Union, Geological Society of America, American Society of Agricultural Engineers, Upsala College, Colorado State University, British Geomorphological Research Group, and the National Academy of Sciences. He is currently applying the results of this research to erosion and river problems.

Walter Schmidt is currently Florida State Geologist and Chief of the Florida Geological Survey. He received a B.A. in geology from the University of South Florida in 1972. He earned his Masters in 1977 and Ph.D. in 1983 from Florida State University. He has been employed by the Florida Geological Survey for 18 years. He has been Chief since 1985. He is a member of the Association of American State Geologists, Geological Society of America, American Institute of Professional Geologists. He is a licensed geologist in the states of Florida, North Carolina, and South Carolina. He has published over forty scientific papers and maps.

Doug Smith is currently employed with Jackson Guard at Eglin Air Force Base, Florida, as a Geographic Information System Analyst. Mr. Smith has received training by Intergraph on their various software packages and is knowledgeable in database design and implementation.

Lawson M. Smith is a senior research geologist in the Geotechnical Laboratory, U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi, and has served as Manager of the Earth Resources Task Area of the Legacy Resources Management Program. Dr. Smith has worked in various geological positions at WES since December 1979. He earned a B.S. from Mississippi State University (geology and geography) in 1975, the M.S. from the University of Southern Mississippi (water resources-physical geography) in 1977, and the Ph.D. from the University of Illinois, Urbana-Champaign (geomorphology/geology) in 1983. At WES, he served as geologist (1979-1983), supervisory geologist (Chief, Regional Geologic Studies Section, 1983-1986, and Chief, Engineering Geology Branch, 1986-1990). He resigned as Chief, Engineering Geology Branch, in September 1990 to return to geological research. Dr. Smith has been involved in a wide range of activities in basic and applied geological research as well as technical assistance to Corps of Engineers districts, U.S. Army installations, other DoD offices, and Federal and State agencies. His primary areas of expertise are geomorphology, engineering geology, wetlands geotechnology, and applied geology. In the field of geomorphology, Dr. Smith has performed more than 60 studies for cultural resource management, natural resource management, civil works engineering projects, and natural hazards assessment. The use of geomorphological information in locating, evaluating, and managing cultural and natural resources has been a particular emphasis in Dr. Smith's activities. Current research activities include wetlands geotechnology, earth resources management at U.S. military installations, and geomorphological approaches to large scale environmental problems. Dr. Smith is a registered geologist in several states and a faculty member of the WES Graduate Institute, holding adjunct professor appointments at Mississippi State University, the University of Southern Mississippi, and Texas A&M University.

Newell Wright received a doctorate in anthropology from Tulane University in 1976. He has conducted field work, both terrestrial and underwater, in England, Scotland, France, Yucatan, Samoa, the Federated States of Micronesia, and in the southeastern United States. He taught at the college level for 20 years and has published numerous articles and reviews and has contributed to several books.

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Appendix C
Preworkshop and Postworkshop Questionnaire Data

Preworkshop Questionnaire

1. I believe that I have a basic understanding of the nature and relevance of earth resource data in overall installation management and planning.
2. My duties at my installation involve the collection and interpretation of earth resource data.
3. At my installation, earth resources are considered of major importance in the management of our resources.
4. Colleagues at my installation are primarily engaged in the collection and interpretation of earth resource data.
5. The collection of earth resource data and its interpretation should be conducted by installation personnel, as opposed to contracting out.
6. Earth resource data are/have been entered into some form of geographic information system or data base at my installation.
7. At my installation, earth resource data are integrated into biological and cultural/historic resource management.
8. I believe that the collection and interpretation of earth resource data are necessary for installation management and planning.

Postworkshop Questionnaire

1. The workshop goals were clearly stated and described.
2. Overall, the stated workshop goals were accomplished.
3. The speakers were well prepared and informative.

4. The content of the talks were directed toward the goals of the workshop.

5. Hotel accommodations were appropriate and satisfactory.

6. The workshop conference room and other facilities were satisfactory.

7. Overall, the workshop personnel were helpful.

8. As a result of the workshop my understanding of earth resources has increased.

9. The information presented at the workshop has improved my understanding of the role of earth resources in the management biological and cultural/historical resources.

10. The information presented at the workshop has improved my understanding of the role of earth resources in the management of my installation.

11. My colleagues at my installation would benefit from attendance at workshop of this type.

12. Although I do not normally collect or work with earth resource data, I feel that I am now able to apply some earth resource data in my work.

13. The collection of earth resource data and its interpretation should be conducted by installation personnel, as opposed to contracting out.

14. The field trip was meaningful.

15. The length of the workshop was about right.

Responses to Questionnaires

Numerical Responses to Questions

a. Strongly Agree (5.0)

b. Agree (4.0)

c. Undecided (3.0)

d. Disagree (2.0)

e. Strongly Disagree (1.0)

Points shown here are the average of the responses for that question.

Preworkshop Questionnaire

1. 4.10/5.00
2. 3.75/5.00
3. 2.21/5.00
4. 2.69/5.00
5. 2.44/5.00
6. 3.00/5.00
7. 3.77/5.00
8. 4.75/5.00

Postworkshop Questionnaire

1. 4.39/5.00
2. 4.48/5.00
3. 4.78/5.00
4. 4.57/5.00
5. 3.90/5.00
6. 4.52/5.00
7. 4.96/5.00
8. 4.61/5.00
9. 4.74/5.00
10. 4.63/5.00
11. 4.41/5.00
12. 4.41/5.00
13. 3.14/5.00
14. 4.43/5.00
15. 4.39/5.00

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A workshop addressing earth resource issues was held at Eglin Air Force Base (AFB), Florida, during the period 9-11 March 1993. The workshop was conducted by the Earth Resources Task Area (ERTA) of the Legacy Resource Management Program (LRMP) and was sponsored by the U.S. Army Engineer Waterways Experiment Station (WES) and Eglin Air Force Base. The purposes of the workshop were to update resource managers about earth resources, to review the results of the Earth Resources Task Area, to receive input from the field, and to identify issues and opportunities for future earth resource stewardship strategies and plans. The workshop was attended by approximately 50 natural and cultural resource personnel representing management and working level professionals. The presenters consisted of Federal and state resource workers, consultants, and academia having experiences in various aspects of resource management. Earth resource presentations included an overview of DoD earth resources, geological assessments as a foundation for environmental management, landforms and resource management, and

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13. (Concluded).

paleontological resources at DoD installations. Cultural resources and their relationships to earth resources included studies at Fort Ord, geoarchaeological approaches to cultural resource management, and earth science, archaeology and resource management in terms of a unified landscape. Biological integration with earth science included Bayou Darter habitat geomorphology in Mississippi, and biodiversity and its determinants. Examples of highly integrated resource management were described relative to DoD installations and the Dolet Hills lignite mine in Louisiana. Presentations on resource management activities at Eglin Air Force Base included the base geographic information system, landscape restoration and ecosystem management, ecological research on the endangered Okaloosa Darter, and proactive cultural resource management. The field trip concentrated on management concerns regarding the operation of clay pits and the darter habitats. Issues and opportunities concerning resource management were debated in informal group work sessions. The issues identified by the groups pertained to perceived lack of command support, insufficient earth resource data and incompatible data systems, lack of training and education, and the need for conducting integrated resource studies. The opportunities identified generally followed the goals of the LRMP.

14. (Concluded).

Air
Atmosphere
Climate
Earth resources
Energy resources
Fossils
Geology
Geomorphology
GIS
Groundwater
Hydrosphere
Integration
Land
Lithosphere
Legacy
Minerals
Natural resource management
Precipitation
Soils
Stream flow
Wetlands